Proposed Code Change

State Form 41186R

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(KEY – ~~Dashed line through material to be deleted~~, underline material to be added)
Use second sheet for any material requiring more space.

Code Title	Edition
2009 Indiana Residential Code	1 st
Section number and title	**Page**
R802.10.5 Truss to wall Connection	
Proponent	**Title**
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PROPOSED CODE CHANGE (Check One)

☐ Change to read as follows X☐ Add to read as follows ☐ Delete and substitute as follows ☐ Delete without substitution

Add exceptions to Section R802.10.5 to read as follows: Exceptions:
1. In exposure category A or B, 24" o/c maximum mono-pitch trusses up to 10' in length that are not girders. Such trusses shall be fastened with three 0.131" diameter × 3" long toenails at each bearing. Truss length shall be the horizontal projection of the truss including all overhangs.
2. In exposure category A or B, 24" o/c maximum trusses that are not mono-pitch trusses up to 30' in length that are not girders. Such trusses shall be fastened with three 0.131" diameter × 3" long toenails at each bearing. Truss length shall be the horizontal projection of the truss including all overhangs.

REASON AND FISCAL IMPACT

INTRODUCTION

IRC code section R802.10.5 treats trusses differently than rafters. The idea that trusses should be treated any different than rafters is based on a faulty understanding of the situation. As all of you know many trusses are very small and have small reactions. Many “trusses” are not trusses by any engineering definition of a truss. They are rather stick framing held together by truss plates rather than nails. If the truss plates were replaced with nails they would work as stick framing according to the rules of stick framing in the IRC. These include gables trusses, valley trusses, open ended hip jacks that consist of a top chord and bottom chord only, and small mono trusses with no interior webs having a top chord, bottom chord, and vertical member at the high end only. The notion that these “trusses” that don’t even fit the definition of a truss should be treated different than the stick framing that they really are seems unreasonable.

There is significant criticism of this code section for a variety of reasons. There are those that feel it is too liberal on large trusses and girders and those who feel it is too conservative. It is a one size fits all approach in a situation where the greater issues lie elsewhere.

A while back we had an amendment that deleted the words “approved connectors” and replaced them with “mechanical fastener or connector”. While our former amendment to this section has been removed it is not really gone. The words fastener and connector are pretty much interchangeable. In most engineers’ minds a nail can be a fastener or a connector. While it does say “approved connectors” all it would take is a request for an interpretation to have toe-nailing become an “approved connector” state wide. When I originally proposed that amendment and it was passed I did it as much to clarify what to me was the obvious meaning as anything. The only thing I really added was the alternative to use the truss drawing reaction when it was less than 175 pounds.

For the purposes of this amendment I used the MiTek truss software. The method of calculating the wind loads is from ASCE 7 2002 Method 2 – Analytical Procedure mean roof height under 60'. I used Main Wind Force Resisting System since this connection between the truss and the wall does not fall under Components and Cladding. I used 90 mph wind, Category II, Exposure B (which would include any subdivision), and enclosed building. I used a gable end zone which is more conservative than an interior zone but since some of the building will always be a gable zone I felt it was necessary. For exposure B any mean roof height from zero to 30' results in the same loads (this is not the case for exposure C and D) so mean roof height for what I did was irrelevant since I have never seen a house with a mean roof height (not maximum roof height) over 30', although I'm sure somewhere one exists. I used a 10 psf top chord dead load and an 8 psf bottom chord dead load. Because dead load helps hold the truss down and fights uplift only 60% of the dead load is used in wind load cases this results in a 6 psf top chord dead load and 4.8 psf bottom chord dead load in the wind cases. I think it would be difficult to argue that the actual dead loads will be less that that.

RAFTER COMPARISON

One problem is that a truss always has wind loads on both sides of it at the same time while a rafter does not. The pressure on one side of the roof fights the uplift on the other side of the roof in many/most wind directions. Rafters act independent of each other and do not have this benefit. The rafter on the pressure side of the roof does not help hold down the rafter on the uplift side of the roof. Another problem you run into is that the truss always has the bottom chord dead load helping hold it down but a rafter often has no ceiling joist attached to it because they often run perpendicular to the rafter.

To demonstrate this I ran a 28' 8/12 common truss and a 14' 8/12 rafter (for a 28' wide house) under the exact same load cases. To make similar condition comparisons the rafter was run 24" o/c like the truss. "Rafter" is for a rafter with no ceiling joist. "Rafter with C.J." is the "Rafter" number with 67 lbs. added which is the reaction of a 14' span ceiling joist with the same dead load (assuming 28' house with center bearing). The reactions at the wall for each of the 6 wind load cases are as follows. Wind parallel means wind parallel to the ridge of the building with two cases being with the truss or rafter at the windward end of the building and two cases being with the truss or rafter at the leeward end of the building. Negative numbers are down. Positive numbers are uplift.

Wind Load Case	Truss	Rafter	Rafter with C.J.
Wind from Left	-218	-103	-170
Wind from Right	-127	100	33
1st Wind Parallel	118	285	218
2nd Wind Parallel	51	146	79
3rd Wind Parallel	-55	-184	-251
4th Wind Parallel	-95	-132	-199

As you can see while the rafter some times has larger down wind case reactions when it has uplift it is always larger whether or not a ceiling joist is attached. This is not going to be the same for every situation and will be less severe for lower pitches but it will generally be something like this and worse for steeper pitches. It is worth noting that custom homes where you are more likely to see stick framing are also more likely to be steep pitches.

TOE-NAIL CAPACITY

In calculating the maximum uplift to use for a toe-nail connection several assumptions needed to be made. For withdrawal the lumber density controls. I assumed SPF lumber (Canadian SPF as opposed to SPF(S) which is from the US). SPF(S) has a slightly lower density. Estimates from the wholesalers I checked with ranged from 95% to 100% of SPF coming into Indiana being from Canada. In checking our invoices I could find none that were not Canadian SPF. There are some other species less dense than SPF such as Aspen, Eastern White Pine, and Western Cedars. However, they are never seen here. The wholesalers I checked said that on rare occasion they have seen Engelmann Spruce-Lodgepole Pine as studs but not plate material.

The nail distributor I checked with said the most commonly sold nail length to framers was 3". I assumed a 3" long 0.131" diameter gun nail. The maximum uplift for the recommended 3 toenail connection is then 124 pounds. This is a conservative number. It is well known (there is discussion on the subject in the commentary to the NDS) that crossing toe-nails from opposite sides enhance the withdrawal capacity significantly. Unfortunately, to my knowledge, this has not been quantified so I made no attempt to take advantage of it.

TRUSS UPLIFT

For checking truss uplift I ran 4/12, 5/12, 6/12, 8/12, 10/12, and 12/12 pitches. At each pitch I ran 8' thru 52' in 4' increments. All trusses were clear span end bearing with 12" overhangs both ends. The maximum uplift for any case and maximum horizontal reaction parallel to the truss for any case are shown below. Horizontal reactions are total horizontal load divided by two to split it evenly between the two bearings.

8' Span			12' Span			16' Span			20' Span		
Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.
4	64	11	4	76	14	4	89	18	4	102	21
5	63	13	5	75	17	5	88	21	5	101	25
6	63	16	6	74	21	6	87	25	6	99	30
8	61	33	8	72	48	8	83	64	8	94	79
10	59	41	10	68	60	10	78	80	10	88	99
12	56	49	12	64	73	12	72	96	12	81	119

24' Span			28' Span			32' Span			36' Span		
Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.
4	115	24	4	129	27	4	142	31	4	155	34
5	114	28	5	127	33	5	140	37	5	153	41
6	112	35	6	124	39	6	137	44	6	149	49
8	106	95	8	118	110	8	129	126	8	141	141
10	99	119	10	109	138	10	120	157	10	130	177
12	90	142	12	99	166	12	108	189	12	117	212

40' Span			44' Span			48' Span			52' Span		
Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.	Pitch	Uplift	Horiz.
4	168	37	4	182	40	4	195	44	4	208	47
5	165	45	5	178	49	5	191	52	5	204	56
6	162	54	6	175	58	6	187	62	6	200	68
8	153	157	8	164	172	8	176	188	8	188	203
10	141	196	10	151	215	10	162	235	10	172	254
12	126	235	12	135	258	12	145	282	12	154	305

As you can see some of these span/pitch combinations are unlikely. A 52' 12/12 truss would be 26.5' tall. While I have seen a truss over 26' tall (after installation of the cap truss) it has been a while.

Using this data you can justify excepting 28' and under trusses for exposure B based on the 124 pound joint capacity. Of the 28' trusses shown only the 4/12 and 5/12 have a slightly higher uplift. As mentioned before the increased capacity caused by cross toe-nailing will exceed this small amount.

THE PROBLEM WITH CLIPS

Clips are not the cure all some may think. While a clip may have a higher uplift capacity than the toe-nails the clip is frequently simply attached to the top plate but what is the top plate attached to? If the top plate is simply nailed to the lower plate all that will happen is that the top plate will come off with the trusses (rafters to for that matter). If the sheathing is factory applied or applied by the framer before he stands the wall up it will not likely be attached to the top plate when it is added. In any case since the sheathing is generally flushed at the bottom and is 8' or 9' on an 8'-1 1/8" or 9'-1 1/8" wall the sheathing barely overlaps with the top plate making fastening nearly impossible. The drywall on the inside adds very little capacity to uplift resistance and is unquantified. In areas where foam sheathing is used, it too has very low unquantified uplift resistance. The answer to this for those who want to sell product is "load path". Tie the top plate to the stud, the stud to the bottom plate the bottom plate to the floor system, etc. with our product. But this is unnecessary. We have no history in this state of problems with things the way they are. Also, the code makes it quite clear in section R802.11 that "load path" need not be addressed until there is a 20 psf uplift pressure.

A lot of the concern over this seems to be over splitting the bottom chord of the truss when toe-nailing. While this does occur on occasion it is not occurring with a frequency to be alarmed about. If it were we would have a history of problems arising from it and we don't. Trusses have been used successfully with toe-nails for a long time and I know of no failures or other problems resulting from damage caused by toe-nails. There are many other quality issues just as bad or worse in the average home and I do not understand the focus on this one. An inspector is free to ask for an investigation or repair drawing if he believes the truss is damaged.

Toe-nails are not that easy to eliminate anyway. In addition to being able to resist uplift this connection needs to be able to resist lateral loads. The wind load pushes the roof sideways as well as lifting it up. As you can see from the chart lateral load takes a big jump between 6/12 and 8/12. For longer 8/12 spans and most steeper trusses the horizontal reaction is higher than the vertical uplift. The lateral load from a truss is not transferred to the wall it bears on. That would require the wall to resist a load perpendicular to it, which it cannot do. What is normally considered to be occurring is the lateral load travels thru the roof diaphragm to the braced wall lines parallel to the trusses or stick framing with the wind load on them. It is then transferred to

those walls by the gables or truss heels on those walls. In a hip roof with no gables it is all the truss heels or rafters transferring this load. Because this pushes sideways or twists the truss heel or rafter, in higher wind or seismic areas (east and west coast) blocking is required between the ends of the trusses or rafters to transfer the load from the roof diaphragm to the wall.

Three of the clips frequently used to tie down trusses are the Simpson H2.5, H2.5A, and H3. They are about as cheep and simple to install as possible. These clips have an uplift capacity of 365, 535 and 320 lbs in SPF lumber. However, their capacity in lateral load parallel to the wall is 150, 110, and 105 pounds. By comparison the 3 toe nail connection has a lateral load capacity of 328 pounds in SPF lumber. Because of this there are those who say that when clips are used they need to be supplemented with toe-nails.

REAL WORLD TRUSSES

Because not all trusses are triangular in shape I felt that there was a need to look at some actually constructed houses to get a feel for what the "average" truss was like. A 14' 8/12 mono truss is going to have similar reactions to the 14' 8/12 rafter with ceiling joist attached. I removed all gables, valleys, and cap trusses because they have continuous bearing under them and are irrelevant to this discussion. I also removed all girder trusses because since a very small girder can have a large uplift if it is carrying several long trusses I did not try to except them at any span. It is worth noting that a beam carrying trusses or stick framing can have all the same problems and does not require any anchorage. This is another one of the many ways that treating trusses different than stick framing makes no sense.

I deliberately tried to include jobs that had long trusses and lots of truss types. I tried to avoid jobs with hip roofs because of the number of small trusses they have and I didn't want to bias the sample with a lot of little trusses. The problem I ran into was the bigger houses with bigger trusses and custom homes were more likely to have hip roofs so I did the best I could. If a truss was not in a gable zone it was analyzed with interior zone loading.

What I found was that the 28' limit worked well for most trusses but mono pitched trusses (those acting more like rafters) were more likely to have larger uplifts than similar span gable shaped trusses. This was in part due to their being more likely to have a high heel at the wall or being more likely to be porch trusses with wind load on the bottom of the bottom chord. I chose a different cutoff span for mono trusses that was in line with the results. This will necessitate the addition of a definition for mono pitched trusses.

In the actual amendment an overall length is used including overhangs of 30' equal to 28' plus a 12" overhang each side. This was considered the best choice because "span" doesn't include cantilevers and "bottom chord projection" doesn't include tray truss areas (top chord bearing trusses from the end of the bottom chord to the bearing). It also does not allow "free" longer overhangs. I also added exposure A this time around. Exposure A has been dropped from ASCE 7 and the IBC but for some reason they keep leaving it in the IRC.

REVIEW RECOMMENDATION
Approve
Disapprove
Approve as amended
Further Study